

Bioinformatics: Virginia Tech Leadership in the Life Sciences

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Virginia Bioinformatics Institute

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Trends Affecting Biology Today

Biology is Being Reinvented by Information Technology

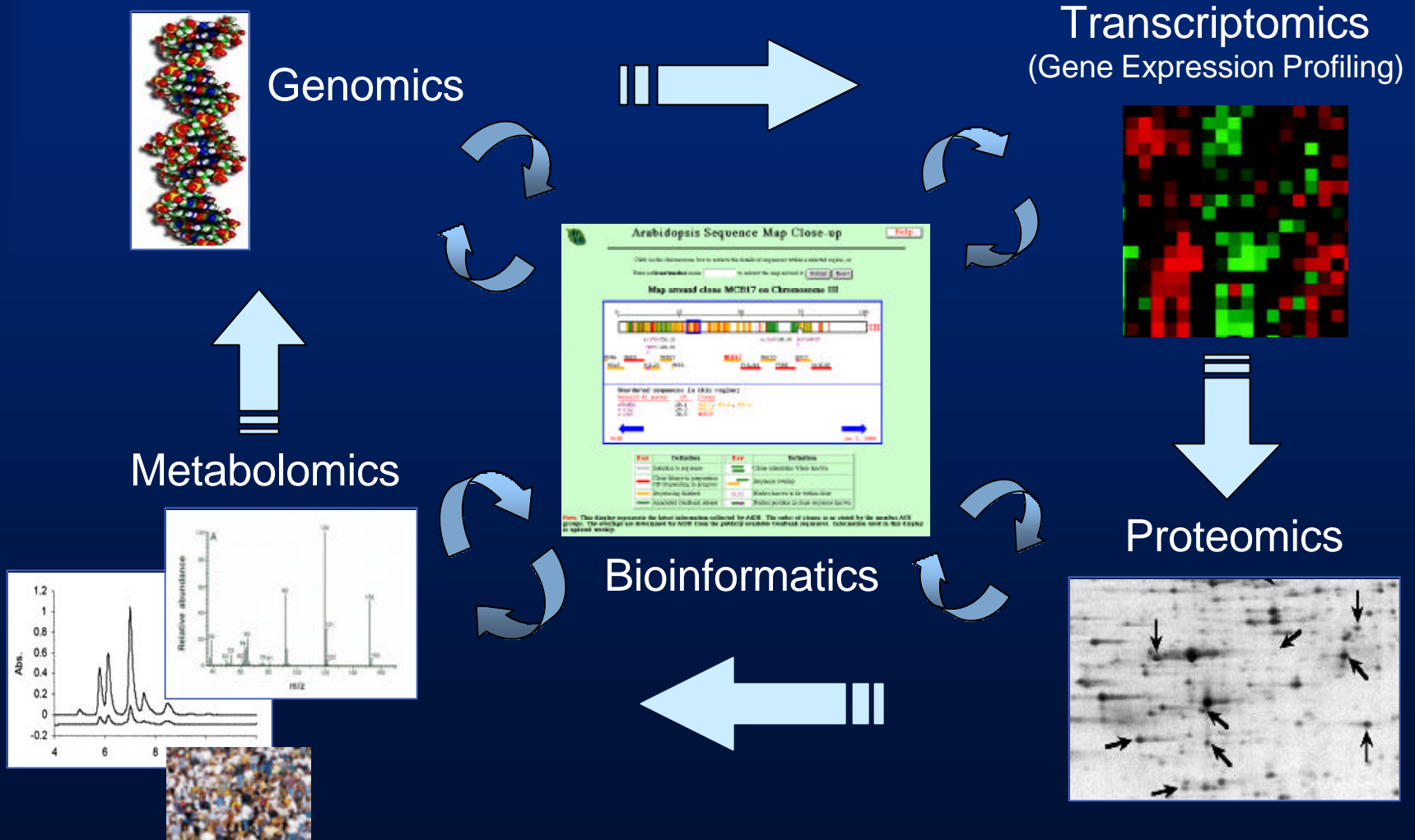
- *in vitro* Biology Evolving to *in silico* Biology

Information Technology is Evolving

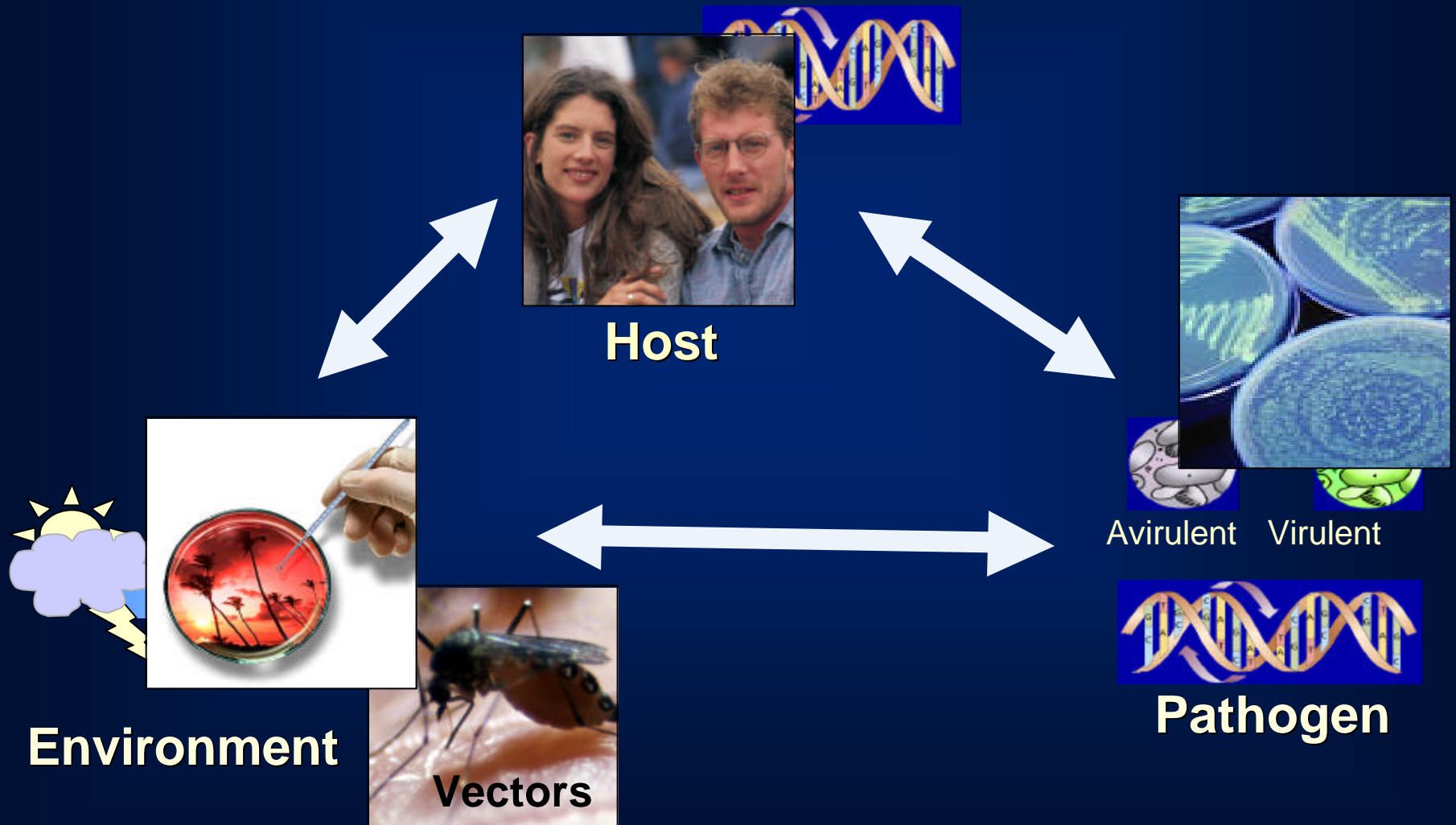
- High Performance Computing Evolving to the *Web Services Model* and *Grid Computing*
- e-business Evolution, Enabled by Ever Increasing IT Capabilities, to Cyber Ecosystems

The Scientific Enterprise is Changing
... to Interdisciplinary System Science

The Missing Piece: Systems Interoperation (Bioinformatics)



Systems Biology: "The Disease Triangle"



Solutions Require Disparate Data Integration

Hosts



Pathogens



Environment



Vectors



Molecule ♦ Cell ♦ Organ ♦ Organism ♦ Habitat ♦ Biodiversity ♦ Ecosystem

Molecular Data + Phenotype Data + Clinical Data + Population Data + Environmental Data

NIH Roadmap

Accelerating Medical Discovery to Improve Health

"The scale and complexity of today's biomedical research problems increasingly demand that scientists move beyond the confines of their own disciplines and explore new organizational models for team science... changes in the way they approach scientific enterprise."

"This demands that we break down barriers among disciplines, as well as among our own institutes and centers... more innovative and effective ways of doing biomedical research and converting that into cures."

Source: "NIH Announces Strategy to Accelerate Medical Research Progress"
September 30, 2003 <http://www.nih.gov/news/pr/sep2003/od-30.htm>

Biological Security

	Human Host	Livestock Host	Crop Host
Intentional Pathogen Introduction	Army FEMA FBI CDC OEP DoE States DHS OSD	ARS NRACC	ARS NRACC
Natural Pathogen Introduction	NIA USDA USDA		
Accidental Pathogen Introduction	FDA USPHS		USDA EPA ARS CSREES APHIS

Common
Bioinformatics
Tools, Data
and People

NFS: Revolutionizing Science and Engineering Through Cyber Infrastructure

Report of the National Science Foundation Blue Ribbon Advisory Panel on Cyber-Infrastructure

"The capacity of this technology [IT] has crossed thresholds that now make possible a comprehensive "cyberinfrastructure" on which types of scientific and engineering knowledge environments and organizations... pursue research in new ways and with increased efficacy."

"Cyberinfrastructure will revolutionize the process of discovery, learning, and innovation across the science and engineering frontier."

Dr. Deborah Crawford, Chair, NSF Cyberinfrastructure Working Group

COVITS 2003

Dr. Irving Wladawsky-Berger
General Manager, IBM Corporation

**IT Driven Deeper into
Business Processes**



Business Ecosystems



**Information Technology
Advances**

VBI Focus: Grants and Contracts that Will Provide the Basis for Cyber Systems Biology

Reverse Engineer the *Disease Triangle* -- Understand the Interaction Between Pathogen, Host, and Environmental Factors.

Comprehensive View of Bioinformatics -- Molecular Processes of Life: Genomics, Transcriptomics, Proteomics, Metabolomics.

Interdisciplinary Research -- Computational Biology, Bioinformatics, Statistical Genetics, IT Infrastructure, Modeling and Simulation, Infectious Diseases, Biological Security

A federation of interconnected data, analysis, individuals, and organizations redefines how research is conducted, and basic, clinical and epidemiological disciplines all contribute to the biomedical

Virginia Bioinformatics Institute

	July 2000	December 2001	December 2002	December 2003	July 2004
Employees	3	21	111	180	220
Scientists (PhD+)	2	12	33	44	64
Contract Base	None	\$8.0 million	\$27.1 million	\$36.5 million	\$47.0 million
New Project Examples	None	Sun COE (\$1.2M) Medicago (\$3.6M) IBM SUR (\$999K) Collaborative Bioinformatics (\$2.5M) William & Mary & INCOGEN (\$3.25M)	<i>Phytophthora</i> genetics (\$6.7M) Johns Hopkins (\$10M) Genome Sequence of <i>Phytophthora</i> (\$2.5M) PathPort Development (\$4M)	PathPort Rel 1 NIGMD BioNetwork Models \$1+M IBM SUR \$600+K NIAID RCE	PathPort Implemen- tation (\$5.6 M) NIAID BRC SSS Proteomics Center

Global Pathogen Portal Web Project (*PathPort*)

6.1 and 6.2 Research: Resource for Warfighter Bio-Security Protection Research

\$4,040,000 FY 2002 -- \$4,902,475 (TBD) FY2004

Application: Data Acquisition, Vetting, Completion, Integration, Consolidation, Annotation, Integrated Views, Comparative Analysis, Collaboratory

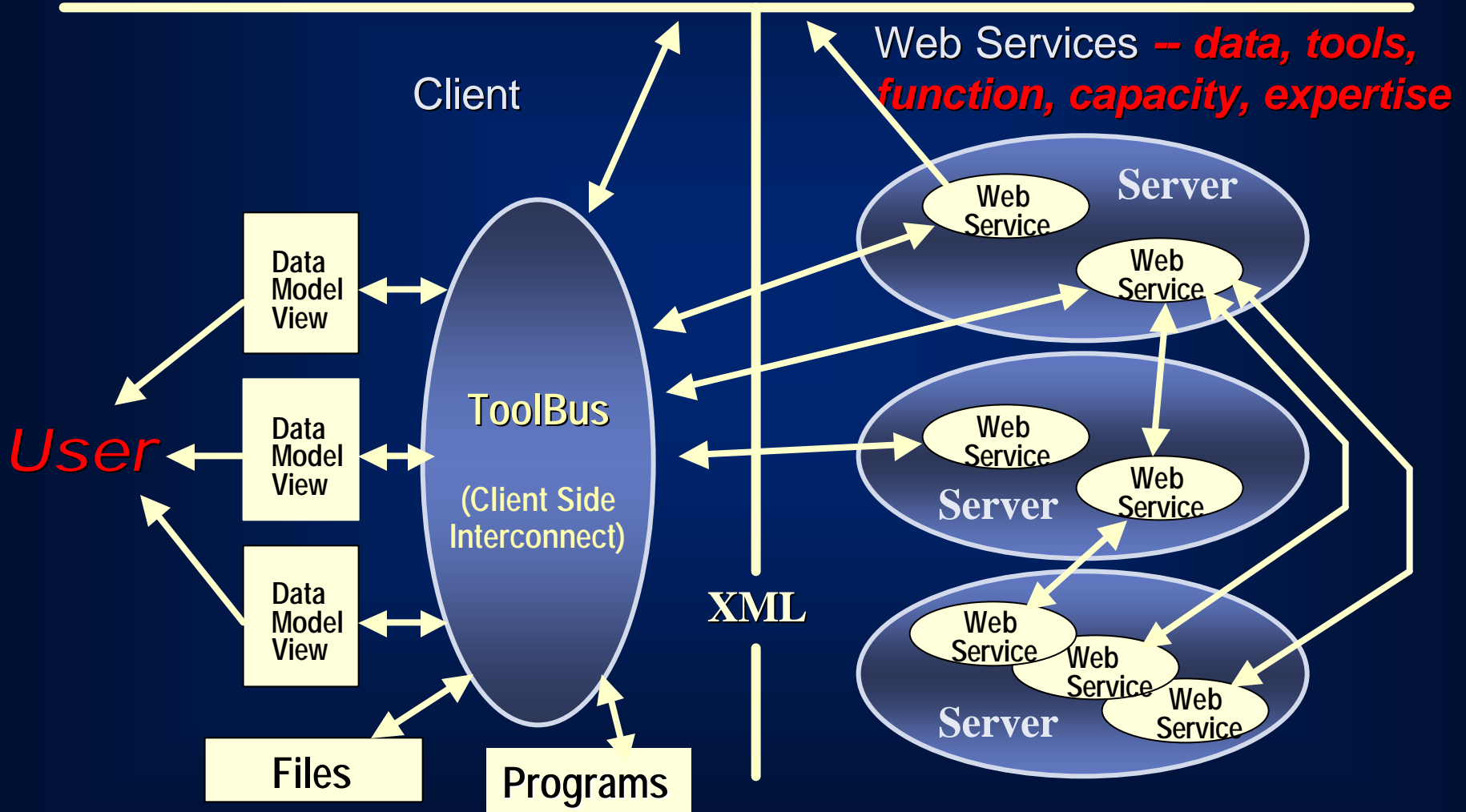
Biology: DNA Sequence Comparisons, Phylogenetic Analysis, Gene Probe-Based, Detection, Bioforensic Reagents and Predictive Systems, Discrimination, Identification, Attribution

Data: DNA, mRNA, Proteins, Metabolites, Characterization of High Priority Pathogens (CDC and NIAID A, B, C list), Near Relatives, Toxicology Signatures

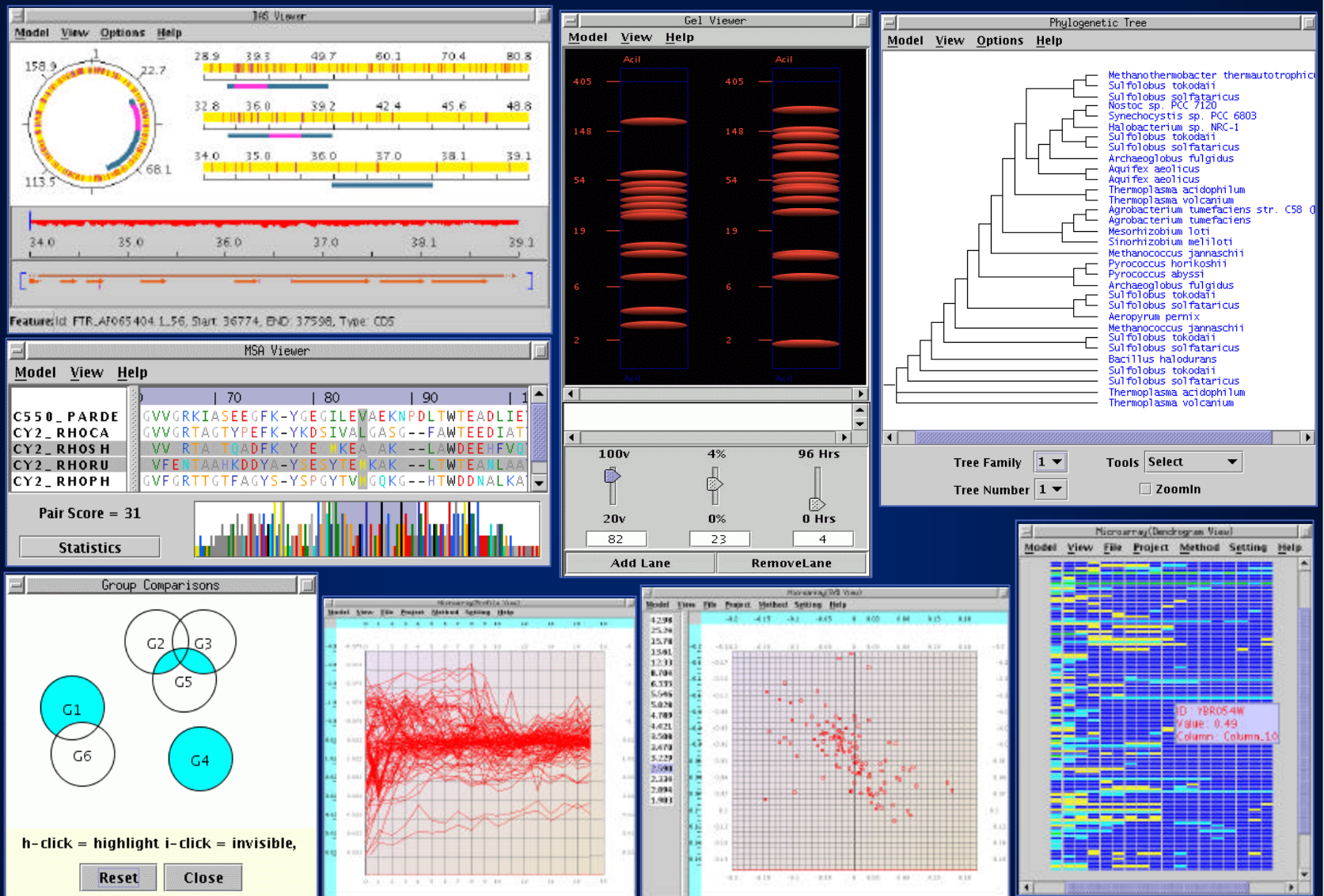
Information Technology: Web Services Model, User-defined Associations, Multiple Domain-Specific Viewers, Data Model Independent, Open Standards

PathPort Architecture

UDDI Registry



PathPort Image



Value of *PathPort* Research

HHS report entitled “Information for Health”

“needed assets [including molecular-level data and tools] are proprietary, complete, fragmented, and dispersed throughout agencies and organizations that lack a mechanism for coordination”.

“The lack of interoperability of data and tools was recognized by HHS as blocking progress on programs such as National Health Information Infrastructure (NHII).”

The Microbe Project (OSTP’s Interagency Working Group on Microbial Genomics)

“microbes (including viruses, bacteria, fungi, protozoa, and micro algae) comprise most of the earth’s biomass, maintain its environments, and hold the key for a myriad of applications improving human health, agriculture, energy and the environment. Yet we know almost nothing about most of them.

NIH Director Harold Varmus Working Group on Biomedical Computing

proposed an initiative to create a new system-level integrative paradigm for biomedical research based on full integration of biocomputing capabilities.

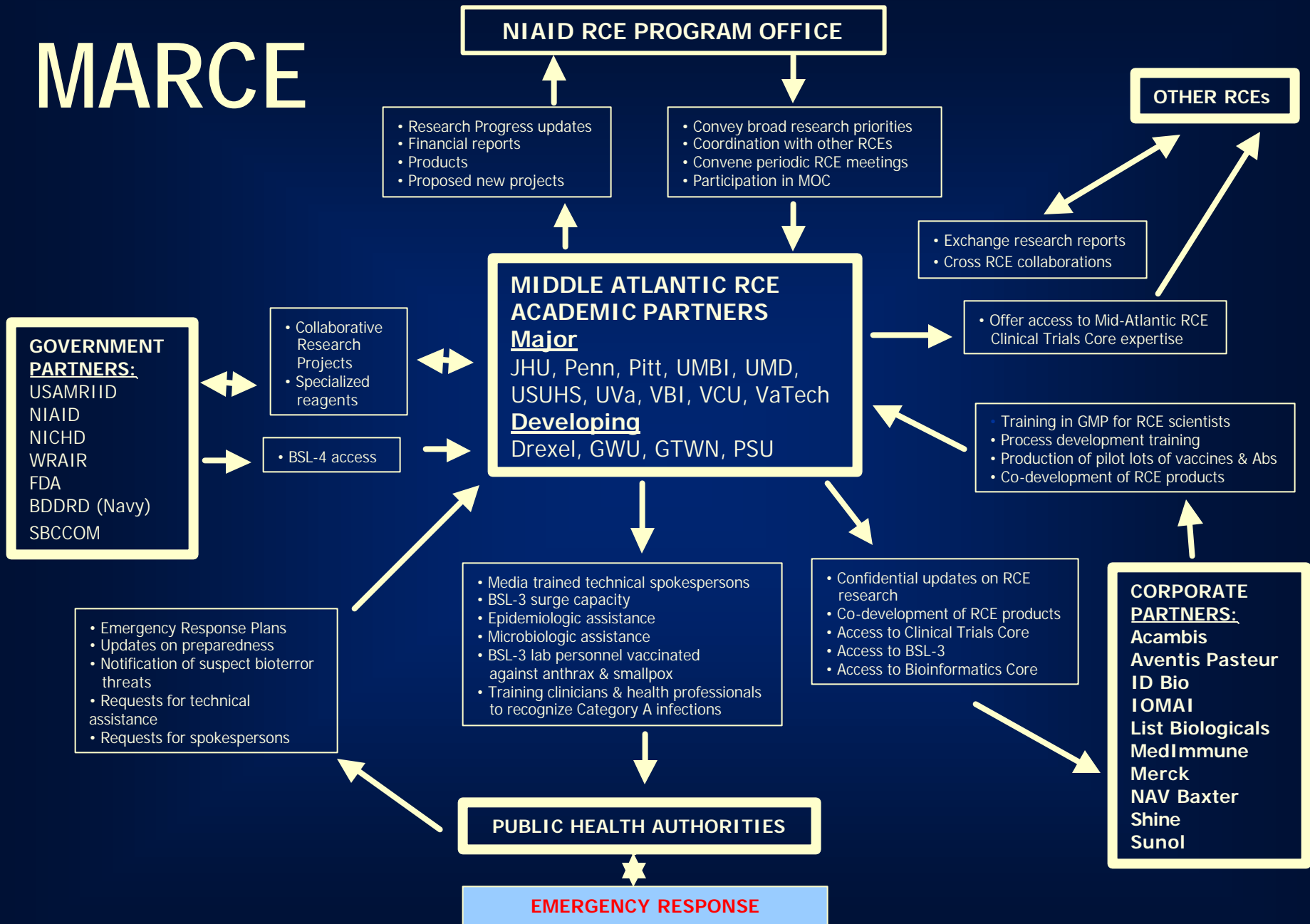
Dr. John H. Marburger III, Science Advisor to the President and Director, OSTP

“The technologies... to protect our homeland from terrorists are available... the single exception is bioterrorism where we just don’t know enough about the pathogens likely to be used as weapons.”

Mid Atlantic Regional Center of Excellence (MARCE) for Biodefense and Emerging Infectious Diseases

- NIAID Resources for Bio-Security Research Community
- \$42 Million, 15-university Mid-Atlantic Center
- Research Supporting Biodefense/Infectious Disease Detection, Control, etc.
- VBI \$1.28 Million + Use
- Bioinformatics and Genomics Core (PathPort/ToolBus Base)

MARCE



SEPTEMBER 4, 2003

VIRGINIA BIOINFORMATICS INSTITUTE CENTRAL TO REGIONAL CENTER OF EXCELLENCE FOR BIODEFENSE AND INFECTIOUS DISEASE RESEARCH

- Virginia Bioinformatics Institute will serve as the Bioinformatics and Genomics Core Facility for the 15-university Mid-Atlantic Center, funded at \$42 million for 5 years.

- VBI will provide high-performance laboratory infrastructure including genomic and gene expression sample analysis and supercomputing capabilities and informatics software platforms through Cores.

- The RCE team will immediately leverage VBI's PathPort for data gathering, storage, analysis, and integration.

- Several diseases—including anthrax, hemorrhagic fever, tularemia, and smallpox—as well as public health response research including needle-free immunization programs will be investigated.

Bioinformatics Resource Center for Biodefense and Emerging Infectious Diseases (BRC)

- NIAID Resources for Genomic, Proteomic, and Bioinformatic Available to the Bio-Security Research Community
- \$10,361,305 Over 5 Years
(\$506K-U of Chicago, \$151K-U of MD, \$147K SSS Inc.)
- Portal and Analysis Engine
 - (PathPort/ToolBus) and CLF
 - NIAID Priority A-C Pathogens (SARS, Brucella, Typhus, Coronaviruses, Hepatitis A, etc.)
 - Biodefense Research
 - Infectious Diseases Research

Biodefense Proteomics Research Center (PRC)

- NIAID Resources for Genomic, Proteomic, and Bioinformatic Resources to the Bio-Security Research Community
- \$8 Million (VBI Role: \$2.8 Million)
- Social and Scientific Systems Inc. (SSS), Georgetown University
- Discover Protein Targets for Next-Generation Vaccines, Therapeutics, Diagnostics
- Proteomic Web Resource for all 5 PRC's- Existing Proteomics Technologies Plus Novel Proteomics Approaches for NIAID Category A-C Pathogens
- PathPort/ToolBus Base

Phytophthora Genome Project

- NSF, USDA, DoE
- \$3.8 Million
- Map *Phytophthora* *Sojae* and *Phytophthora* *Ramorum* Genomes
- Woody Ornamental Fungal Pathogen (Sudden Oak Death, Soybean, Shrubs--*Rhododendron*, *Laurel*, *Azalea*, *Camellia*)

[Gene-for-gene recognition between *P. sojae* and soybean]

[Recognition of *Phytophthora parasitica* elicitor proteins by tobacco]

[Quantitative resistance in soybean against *P. sojae*]

[High throughput functional genomics of *P. sojae*]

[Cross-kingdom comparative genomics of pathogens, *Phytophthora*, malaria...]

[Population genomics of microbial communities]

VBI Researcher on Team Awarded \$1.8M NSF *Arabidopsis* 2010 Project

NSF \$1.8 million Award to determine function of 24 genes in *Arabidopsis*

VBI, University of Michigan, The Salk Institute for Biological Studies

Understand function of the SABATH family of methyltransferase genes in plants, which affect plant physiology and reproduction by mediating processes controlled by signaling and hormone molecules

Understanding this gene function will help researchers determine how plants respond to adverse growing conditions, leading to new generations of crop cultivars with improved yield and nutritional value



JHU-VBI Collaboration

- Research Malaria, AIDS, and Tuberculosis
- Technology, Software, and Database Platforms (PathPort/ToolBus)
- Teams provided 14 publications/ 12 presentations
- \$76 Million Grant proposals submitted FY 04

VBI's Core Laboratory Facility

- Genomics
- Transcriptomics
- Proteomics
- Metabolomics



New Location and New Services and Upgrades

- CLF is now housed in Bioinformatics Facility I on Virginia Tech's campus
- The move brings the CLF closer to service the needs of the Virginia Tech research community
- CLF announces a new service via its proteomics group that provides better detection limits and comparable resolution in a gel-free environment

VBI's Core Computational Facility

- High Performance Computing
- Data storage
- Visualization
- High-speed connectivity
- Data base administration



New Developments in the CCF

- The CCF staff has created a mobile installation of PathPort services to support site training in VBI's PathPort/ToolBus federation



VBI's Funded Partnerships

GLOBAL

- Acambis
- Aventis Pasteur
- European Media Labs, Heidelberg
- IBM Life Sciences SUR
- I.D. bio
- Laboratoire Bordelais de Recherche Informatique (LaBRI, France)
- Merck
- Monsanto
- Philip Morris - USA
- Shire
- Sun Microsystems COE in Bioinformatics

NATIONAL

- Altuda Energy Corporation
- College of William & Mary
- Department of Energy Joint Genome Institute
- Drexel University
- East Tennessee University
- George Mason University
- George Washington University
- Georgetown University
- INCOGEN
- Infigen, Inc.
- IOMAI Corporation
- Johns Hopkins University
- List Biologicals
- Los Alamos National Laboratory
- MedImmune
- NAV Baxter
- Ohio State University
- Oklahoma State University
- Samuel Roberts Noble Foundation
- RDECOM (DoD)
- Sunol
- The Salk Institute for Biological Studies
- USAMRIID (DoD)
- Uniformed Services University of the Health Sciences (DOD)
- Univ. of California-Berkeley
- Univ. of Maryland
- Univ. of Michigan
- Univ. of Missouri
- Univ. of Pennsylvania
- Univ. of Pittsburgh
- University Nevada-Reno
- Univ. of Vermont
- Univ. of Virginia
- Univ. of Washington
- Virginia Commonwealth University
- West Virginia University

VBI Goal

The goal of VBI is to become the globally-dominate research institution in systems biology defined by four trends:

- IT-Driven Reinvention of Biology
- High Performance Computing Evolving to the *Web Services Model* and *Grid Computing*
- e-business Evolution to Cyber Ecosystems
- Scientific Discovery Evolving to Interdisciplinary System Science

Specifically, VBI will lead in cyber Infrastructures for pathosystem biology

- Academic and Research Excellence
- Leadership in Cyber Ecosystem for Biology
- Leading Contract Research Institution
- Focus on Patho-Systems Biology Extended to Epidemiology
- Engine for IP Commercialization and Entrepreneurial Ventures